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A HEAT RESISTANT EXPLOSIVE FILL FOR LEADS AND BOOSTERS (U)

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A HEAT RESISTANT EXPLOSIVE FILL FOR LEADS AND BOOSTERS (U)

By J. N. Ayres
L. D. Hampton

ABSTRACT: The sensitivity of small highly confined charges of DATB has been investigated. The charges were press-loaded into axially drilled brass cylinders, either 1.0-inch or 2.0-inches outside diameter, 0.1 to 0.6-inch inside diameter, and 0.25 to 1.0 inches in length. The investigation was a preliminary survey from which it is held that DATB has sufficient sensitivity to be used as a heat-resistant explosive fill for leads and boosters. This abstract is Confidential.

Explosion Dynamics Division
Explosions Research Department
U. S. NAVAL ORDNANCE LABORATORY
WHITE OAK, MARYLAND

NOLTR 63-50 15 May 1963

A HEAT RESISTANT EXPLOSIVE FILL FOR LEADS AND BOOSTERS (U)

This report describes work to determine whether or not DATB would be suitable as an explosive material for high temperature resistant leads and boosters. The work was conducted in the Explosion Dynamics Division, Explosions Research Department under Task No. RUME-4E-000/212-1/F008-10-004 (Problem 012), Study of Explosive Properties. Although the testing was limited, the data show that DATB has sufficient sensitivity and output to serve as a lead and booster explosive. Since DATB is also capable of withstanding higher temperatures than the usual explosives being used for these components, this report should be of interest to missile and space vehicle designers faced with the utilization of explosives at high temperatures.

R. E. ODENING
Captain, USN
Commander

C. J. ARONSON
By direction

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A HEAT RESISTANT EXPLOSIVE FILL FOR LEADS AND BOOSTERS (U)

INTRODUCTION

This report presents the results of a preliminary exploration of the effects of charge size, initiation strength, and confinement on the output of small, pressed* DATB charges. These studies were undertaken to determine the feasibility of using DATB for high-temperature resistant leads and boosters. The data are scanty. Many obvious experiments involving possible combinations of parameters have not yet been tried. For those combinations which have been tried, the sample size has been small (four or five shots). The data nonetheless reveal very interesting relationships which suggest directions for future study.

EXPERIMENTAL PROCEDURE AND DATA TREATMENT

The data for this study were obtained with experimental setups patterned after the revised Small Scale Gap Test.1/ These setups, shown in Figure 1, consist of an initiator firing into a cylindrical acceptor charge which rests on a cylindrical steel witness block. The parameters explored were wall thickness (ranging from zero to nearly an inch), column length (ranging from 0.25 to 1.0 inch), column diameter (ranging from 0.10 to 0.60 inch), and initiator strength. Very few of the many possible parametric combinations were studied. The performance of the explosive under the various test combinations that were used was evaluated by the measurement of the denting of steel witness blocks.2/ The dent produced by the acceptor explosive was taken as the deepest penetration below the plane of the undisturbed surface.

As is suggested by equation 15 of reference 2, the ratio of the dent depth to the charge radius should be constant for highly confined charges of a given density and composition after steady-state detonation has been established. For the

* This report will deal with charges pressed at only one pressure (10K PSI) from pure DATB. The charge increment length is chosen to be equal to or less than the charge diameter. The DATB does not have any Zytel binder such as is used in the PBX compositions which are used in the fabrication of warheads.

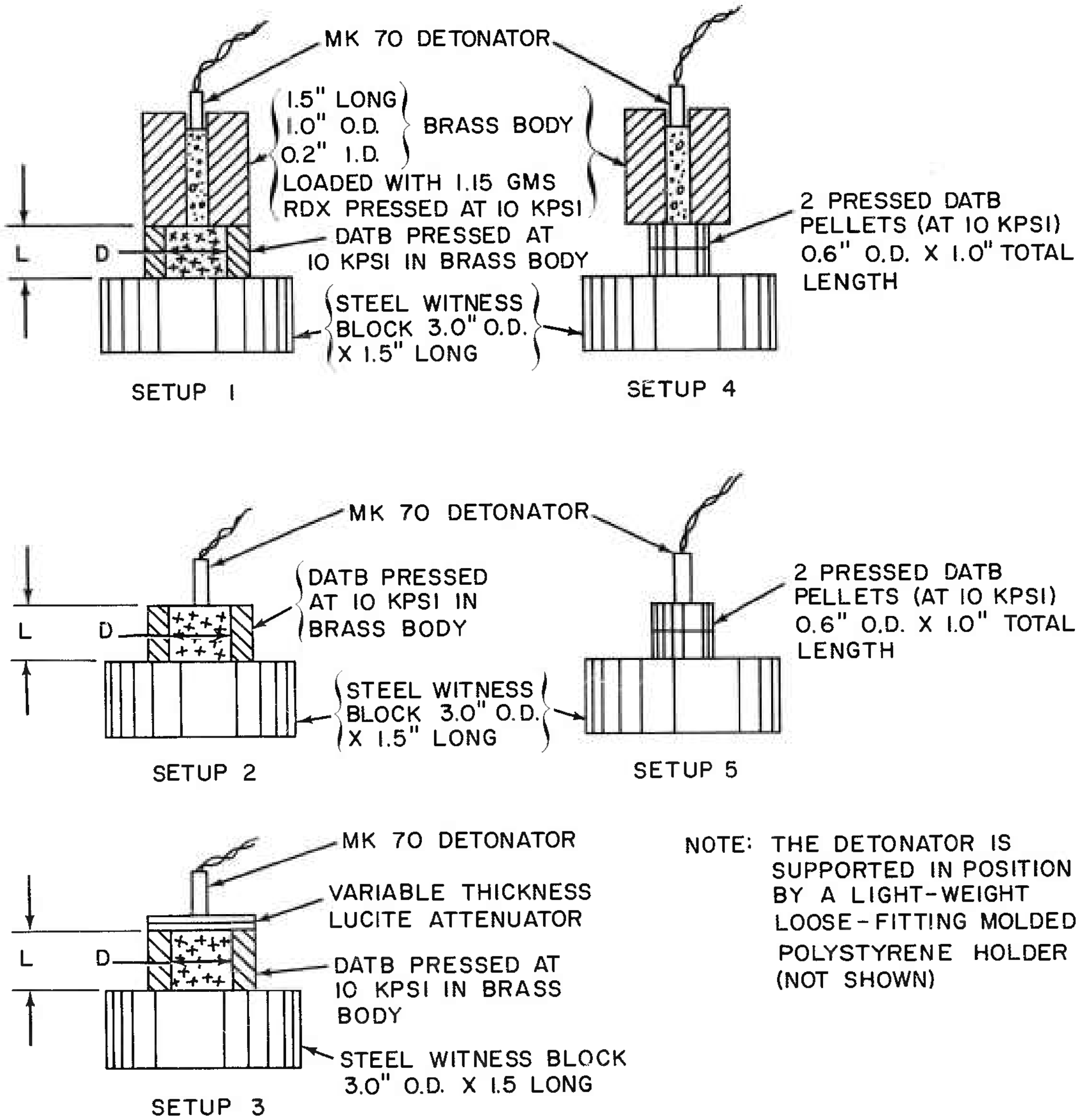

FIG. 1 EXPERIMENTAL SETUPS

purpose of this report a transformation was made so that in addition to presenting data as observed, the output readings of column diameters other than 0.1875 inch have been normalized to that diameter by multiplying the observed dent by the ratio

$$\frac{0.''1875}{\text{column diameter}}$$

The individual data points are to be found in Tables A-1, A-2, and A-3 of Appendix A. These data have been summarized in the main body of the report in Table 1. In each of the graphic displays of the observed relationships (Figures 2, 3, and 4) the individual data points have been plotted to show the variability in regard to the fitted curve as well as the usual plotting of the relationship between appropriate averaged values.

Pronounced variations were noted in the shape of the dent -- particularly in the differences in output of charges loaded in 2.0 inch bodies compared to those in 1.0 inch bodies. Traverses which were made across the blocks on a diametral path running through the point of deepest dent were used to generate the dent profiles some of which are shown in Figures 5 through 9. This measurement was carried out using a dial gage mounted on a lathe bed with cross-feed used to traverse the block under the dial gage. The precision of the traverse motion is probably better than ±0.''002. The precision of depth measurements on nearly level surfaces is better than ±0.001 inch. Considerable error in depth may be expected in the detail of sharply inclined sides of some of the dent profiles because of the finite diamter of the dial gage probe. For this reason, computations of the volume of the dent by revolution of the observed area would be expected to under-estimate the true volume.

DECOUPLING STUDIES

DATB is classified as a relatively insensitive high explosive. Yet it has been used as the base charge in electric detonators and as a core-load for Mild Detonating Fuse (MDF), thus indicating that it will support detonation at small diameters. The first series of tests was therefore designed to explore its properties as a lead explosive. It was decided to measure the output of the 0.1875-inch diameter DATB charges pressed at 10K psi. The effects of column length and initiator strength on the output would be observed. The charge holders were 1.0-inch diameter brass cylinders with axial holes 0.1875 inch in diameter and of four different lengths; 0.25 inch, 0.50 inch, 0.75 inch, and 1.00 inch. Three initiators were used:

TABLE 1

THE AVERAGE DENT OUTPUTS OBSERVED FOR VARIOUS INITIATOR AND DATB-CHARGE CONFIGURATIONS

Charge Diameter (in)	Charge Length (in)	Confinement	DENT (mils) When Initiated By-				
			SSGT Donor	Mk. 70 Det.	Mk. 70 Det Attenuated With		
					42 mils Lucite	64 mils Lucite	70 mils Lucite
0.100	1.00	Brass	20.6				
0.150	1.00	Brass	31.9				
0.1875	0.25	Brass	56.0	26.7		24.0	
0.1875	0.50	Brass	48.7	34.9		34.2	
0.1875	0.75	Brass	45.2	39.7		36.6	
0.1875	1.00	Brass	42.4	41.0	41.6	40.0	39.8
0.200	1.00	Brass	46.8				
0.250	1.00	Brass	60.9				
0.300	1.00	Brass	71.5				
0.400	1.00	Brass	80.9	77.7		74.8	
0.500	1.00	Brass	93.9				
0.600	1.00	Brass	99.7	96.9			
0.600	1.00	Air	56.3	55.8			
0.300	1.00	Brass*	60.3				
0.400	1.00	Brass*	78.7				
0.500	1.00	Brass*	94.5				
0.600	1.00	Brass*	111.7				

* 2"0 Body O.D. (All other brass-confined charges: 1"0 O.D.)

(1) The Small Scale Gap Test donor; to furnish the highest shock pressure.

(2) The Detonator Mk 70 Mod 0; to provide a moderate shock pressure.

(3) The Detonator Mk 70 Mod 0 attenuated by a Lucite barrier; to provide a weak shock just strong enough to start detonation.*

The results of these experiments are plotted in Figure 2. The output of initiators (1) and (2) (as measured by the depth of dent in a steel block) are plotted at a zero column length of DATB. As the DATB column length is increased it can be seen that the dent changes asymptotically from a value characteristic of the initiator to a value of about 40 or 42 mils which would be expected of long columns of DATB loaded under the given conditions. Decoupling from the initiators is nearly complete in one inch. The center and right-hand plots in Figure 2 are included to show the scatter of the individual data points and to demonstrate that the observed phenomena are significant and reproducible.

The results with DATB appear to be consistent with work done in years past on tetryl.3/ By correcting the dents observed with tetryl at 0.200 inch diameter to what would be expected at a 0.1875-inch diameter, it was found that tetryl would decouple in about 3/4 to 1 inch at a value of about 47 mils, as shown by the + symbols in Figure 2. If the output of DATB is assumed to be about 0.89 of tetryl, the tetryl data fall reasonably well on the observed DATB curve, as shown by the x symbols in Figure 2.

COLUMN DIAMETER AND CONFINEMENT STUDIES

The other phase of this program was to study the effect of column diameter, and to some extent confinement, on the output of 1.0-inch long columns of DATB pressed at 10K PSI. In all diameters, ranging from 0.1 inch to 0.6 inch, the confined charges support detonation and have similar decoupling. By inspection of the solid line of Figure 3 it can be seen that

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* This barrier size was selected as being representative of the interface thickness encountered in some weapon systems and nearly as thick as the barrier size at which some failures to initiate were observed.

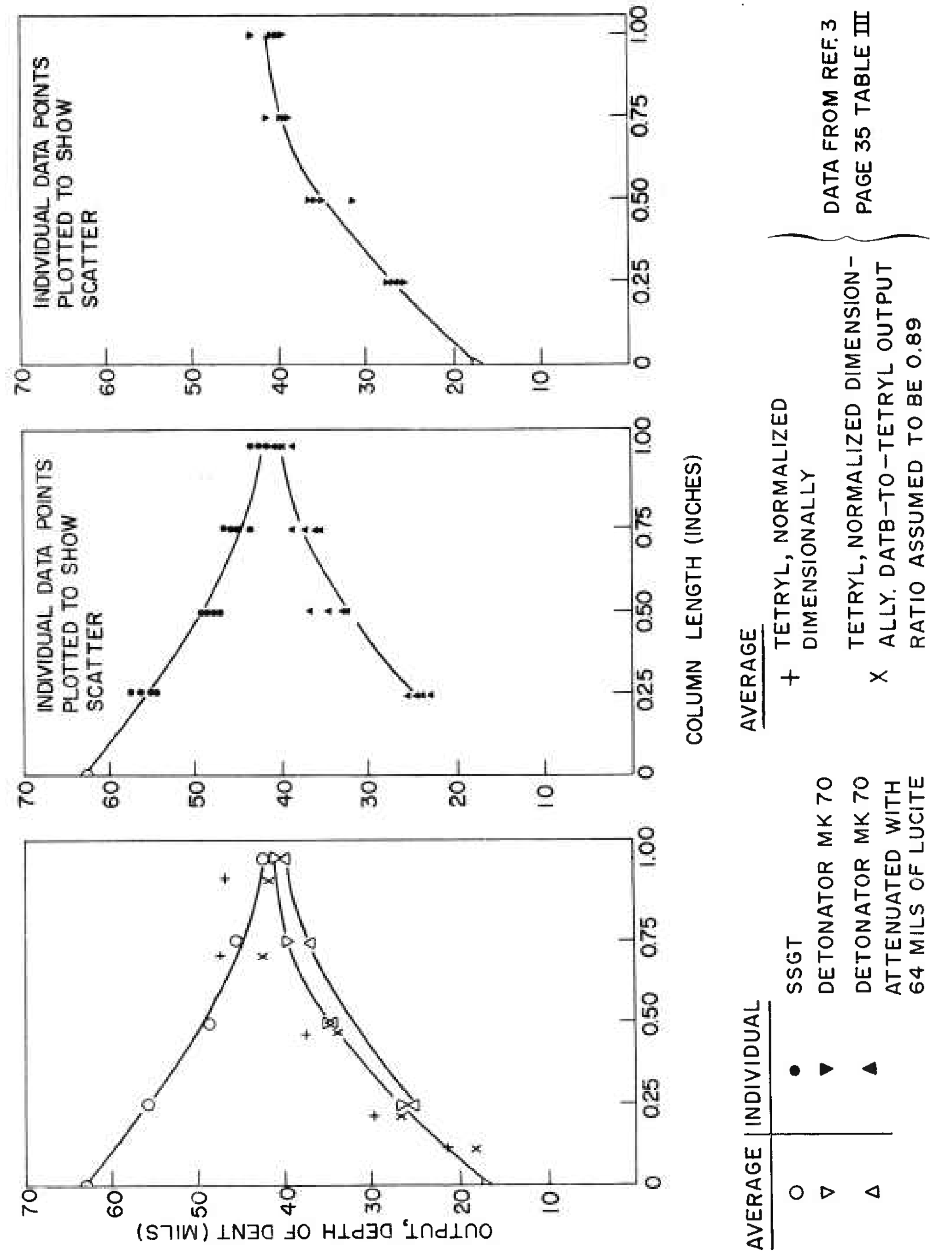

FIG. 2 THE EFFECT OF COLUMN LENGTH AND INITIATOR STRENGTH ON THE OUTPUT OF 0."1875-DIAMETER PRESSED DATB CHARGES

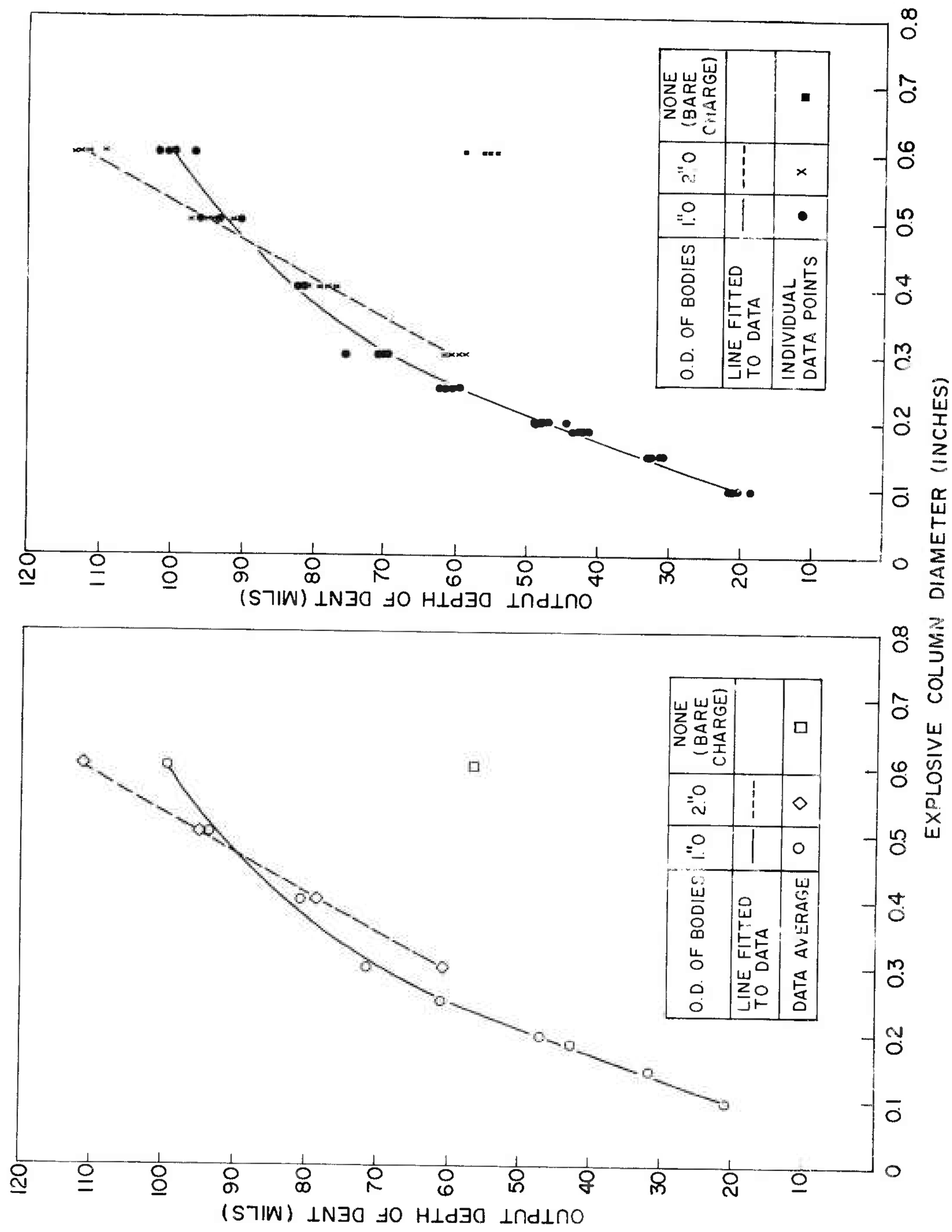

FIG.3 EFFECT OF CHARGE COLUMN DIAMETER ON THE OUTPUT OF 1.''0-LONG DATB CHARGES

the output falls off essentially linearly with diameter between diameters of 0.3 inch and 0.1 inch. There is, as yet, no sudden break in the curve toward zero dent with decreasing diameter such as would be seen if the failure diameter were encountered.

Above 0.3-inch diameter, a curvature is noticed indicating that the output dent is not increasing with the column diameter as rapidly as would be expected from the scaling law. The most obvious reason for this curvature would be the loss in confinement with increasing charge diameter as a result of holding the charge case diameter to 1.0 inch. To check this effect, 2.0 inch outside diameter pieces were used to get data for charge diameters of 0.3, 0.4, 0.5, and 0.6 inches (data plotted as a dashed line in Figure 3). Since the straight line relationship is restored, this interpretation is tenable. This is further borne out by comparing the data after they have been normalized to the 0.1875-inch column by the scaling law (Figure 4).

The plots in Figures 3 and 4, and relevant tabulated data, are in terms of depth of dent and not the more fundamental parameter of volume of dent. Dent volumes were not measured. Dent profiles, however, were taken in a plane passing as close as possible through the point of deepest dent. Figure 5 compares typical profiles for each of the charge diameters studied in 1.0-inch diameter, 1.0-inch long bodies. Vertical tick marks have been drawn on the profiles to give a reference as to the diameter of the original charge.

The reader is cautioned to note that the vertical scale of all the profiles is exaggerated in comparison to the horizontal scale. Figure 6 is a similar comparison of the 2.0-inch outside diameter charges. From these profiles it can be seen that the variation in shape of the dent is not as great within each of the types of outside diameters as it is between the two types. The extra constraint to the steel block offered by the larger mass of brass in the 2.0-inch diameter system leads to a much different shape by preventing upsetting of the steel. The cross-over of the 1.0-inch and 2.0-inch diameter curves in Figure 3 is much less puzzling when the difference in profiles is considered.

Figure 7 has been included to show as typical the similarity of profile that is observed for replicate experiments. Figure 8 has been included to show typical comparisons of the effect of the change of body outside diameter on the profile.

By selecting appropriate data it is possible to show (Table 2) that the variation in explosive charge diameter does not have an appreciable effect on the decoupling. That is, the

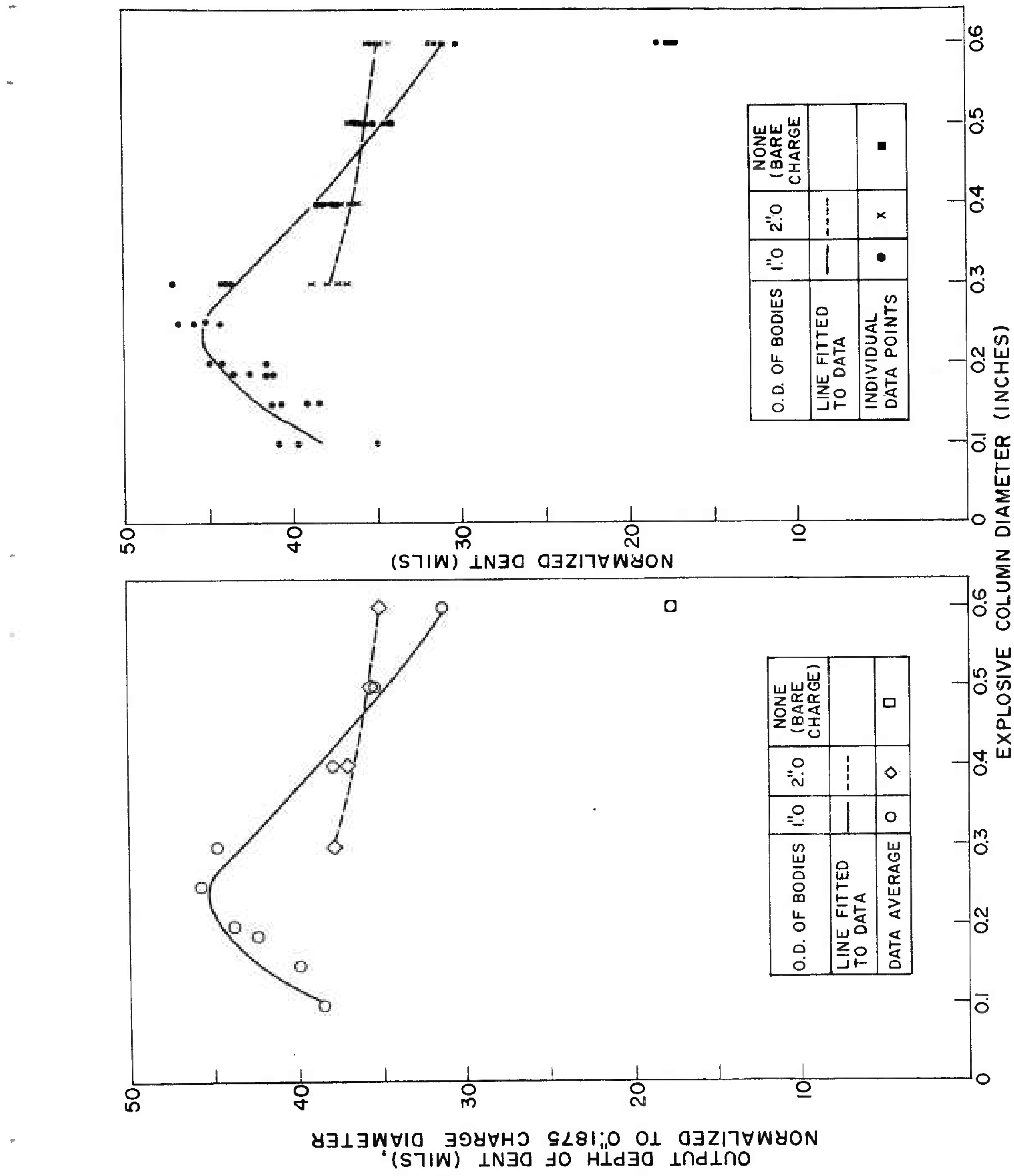

FIG. 4 THE EFFECT OF CHARGE COLUMN DIAMETER ON THE OUTPUT OF 1."0 LONG DATB CHARGES; DENT VALUES NORMALIZED TO 0."1875-CHARGE DIAMETER

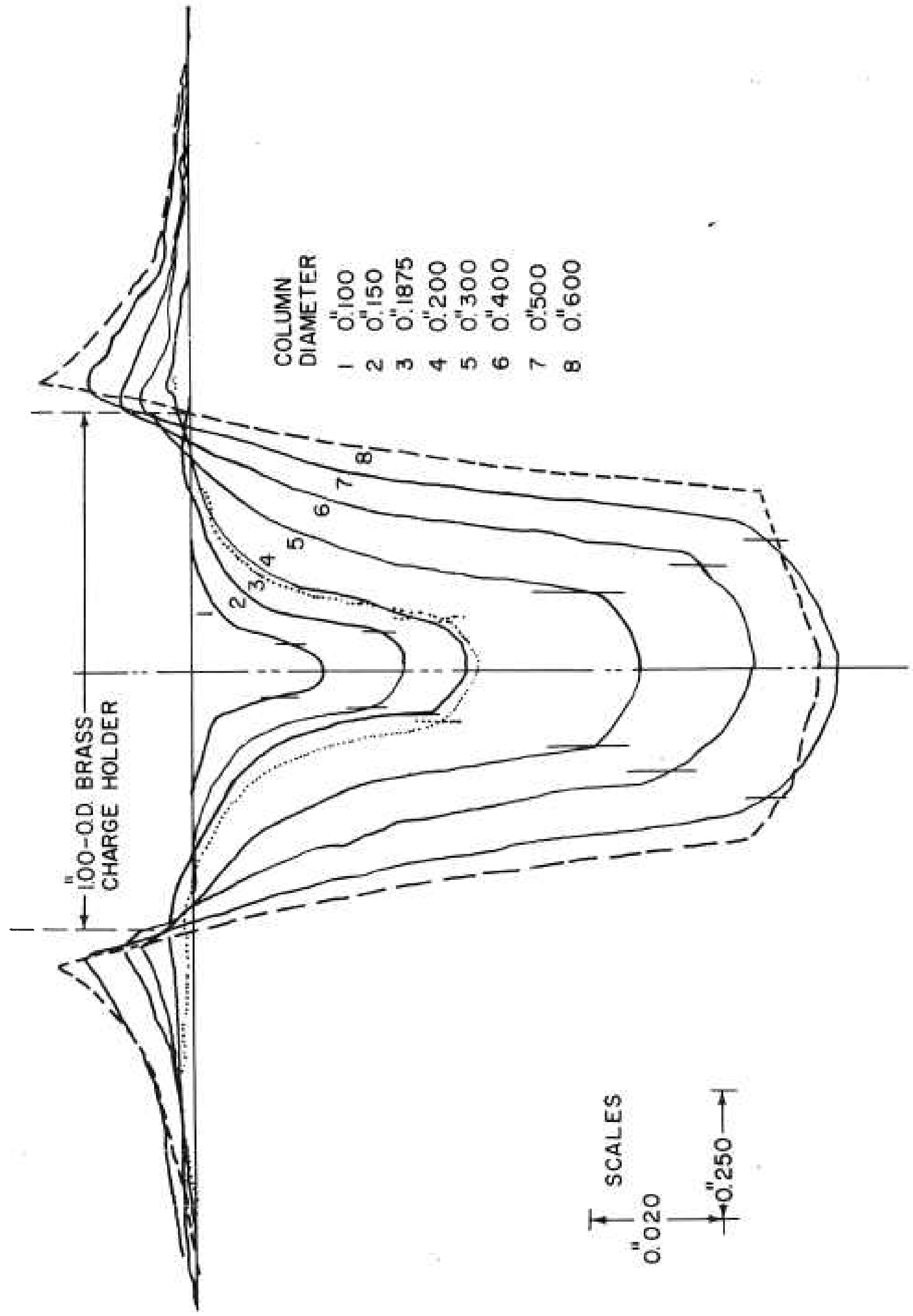

FIG. 5 DENT PROFILE VARIATION WITH CHARGE DIAMETER
1.00"-O.D. CHARGE HOLDER

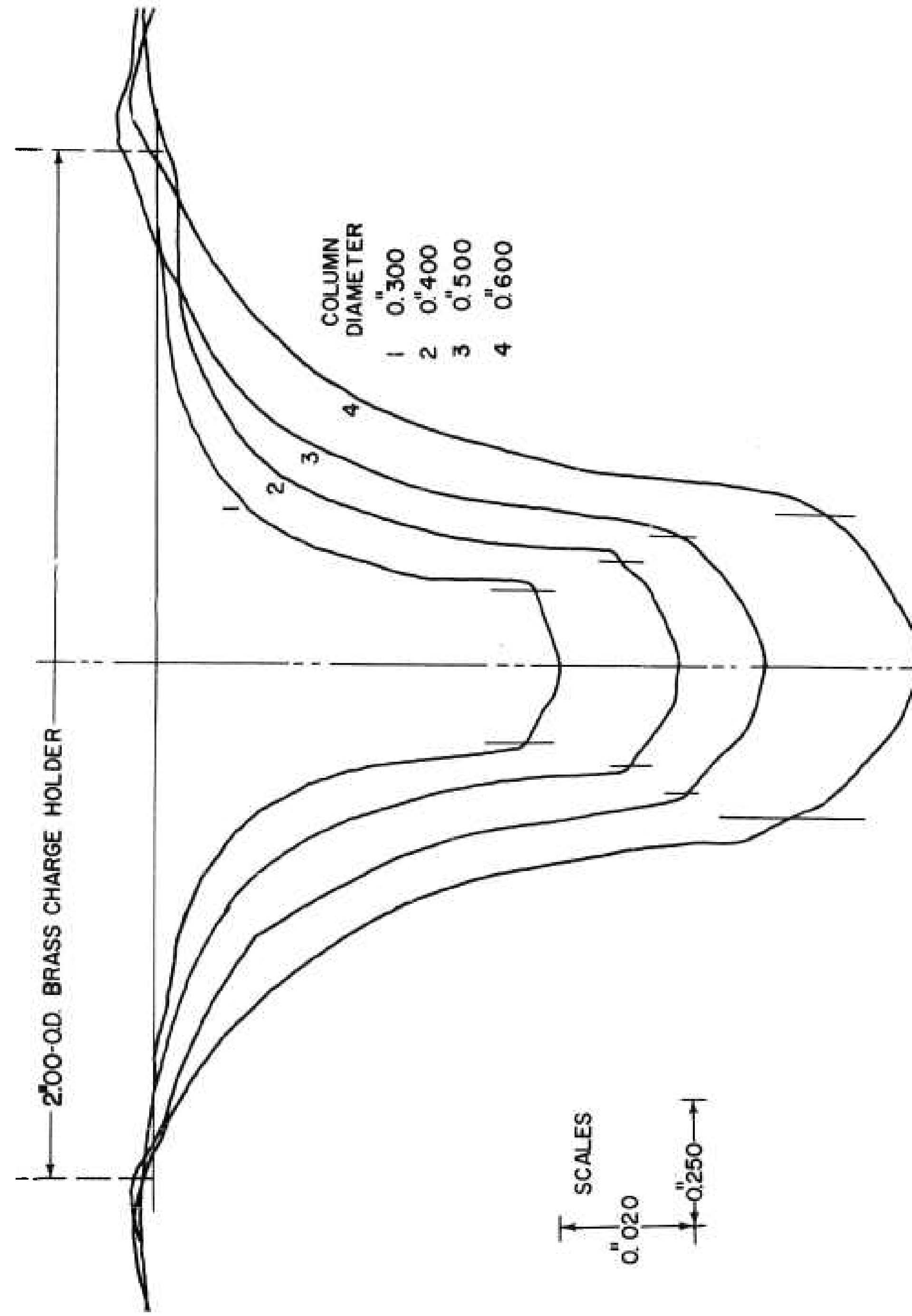

FIG. 6 DENT PROFILE VARIATION WITH CHARGE DIAMETER 2.00"-O.D CHARGE HOLDER

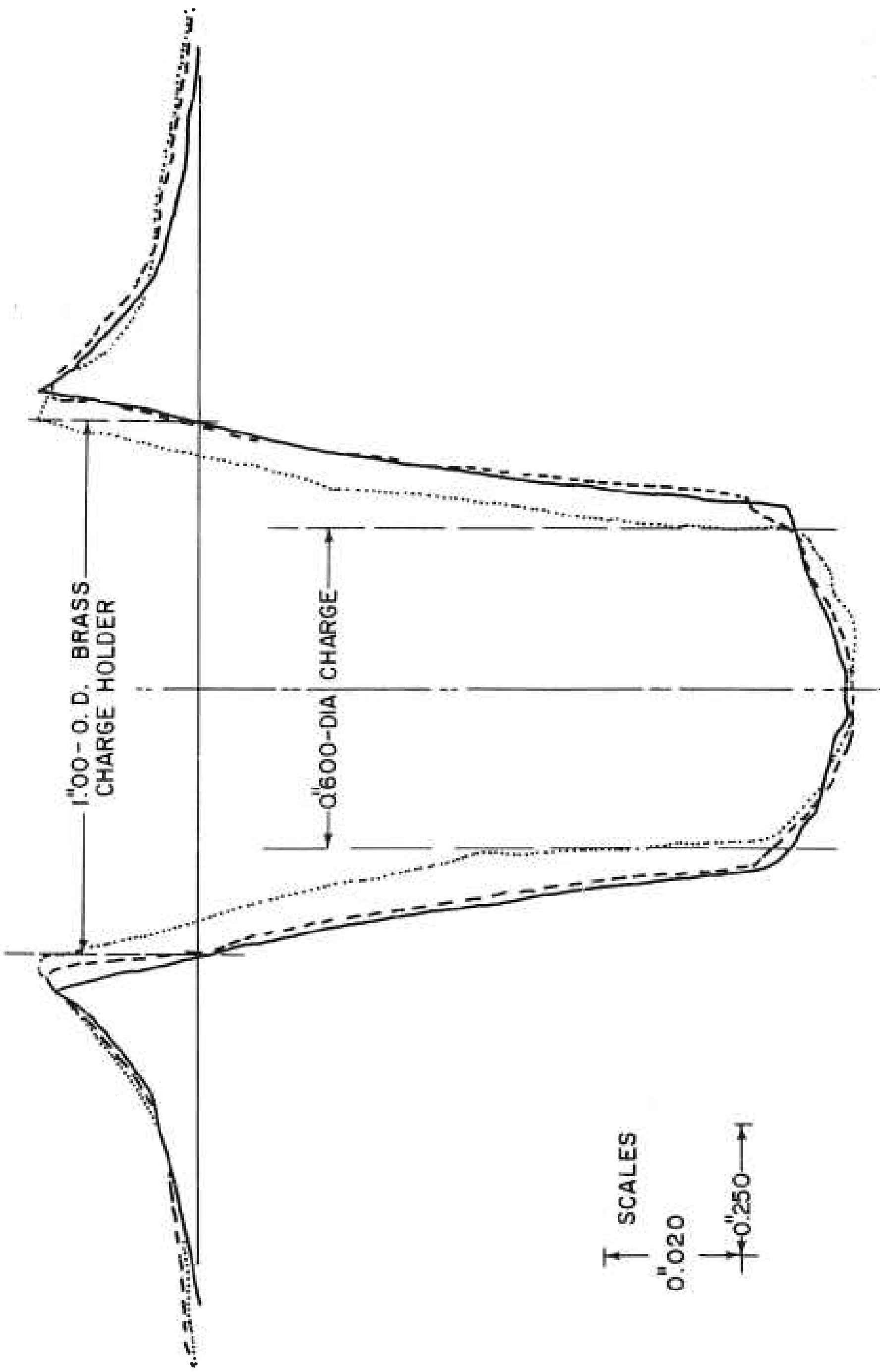

FIG. 7 DENT PROFILE VARIABILITY 0.600-DIA. CHARGES
1.00-O.D. CHARGE HOLDER

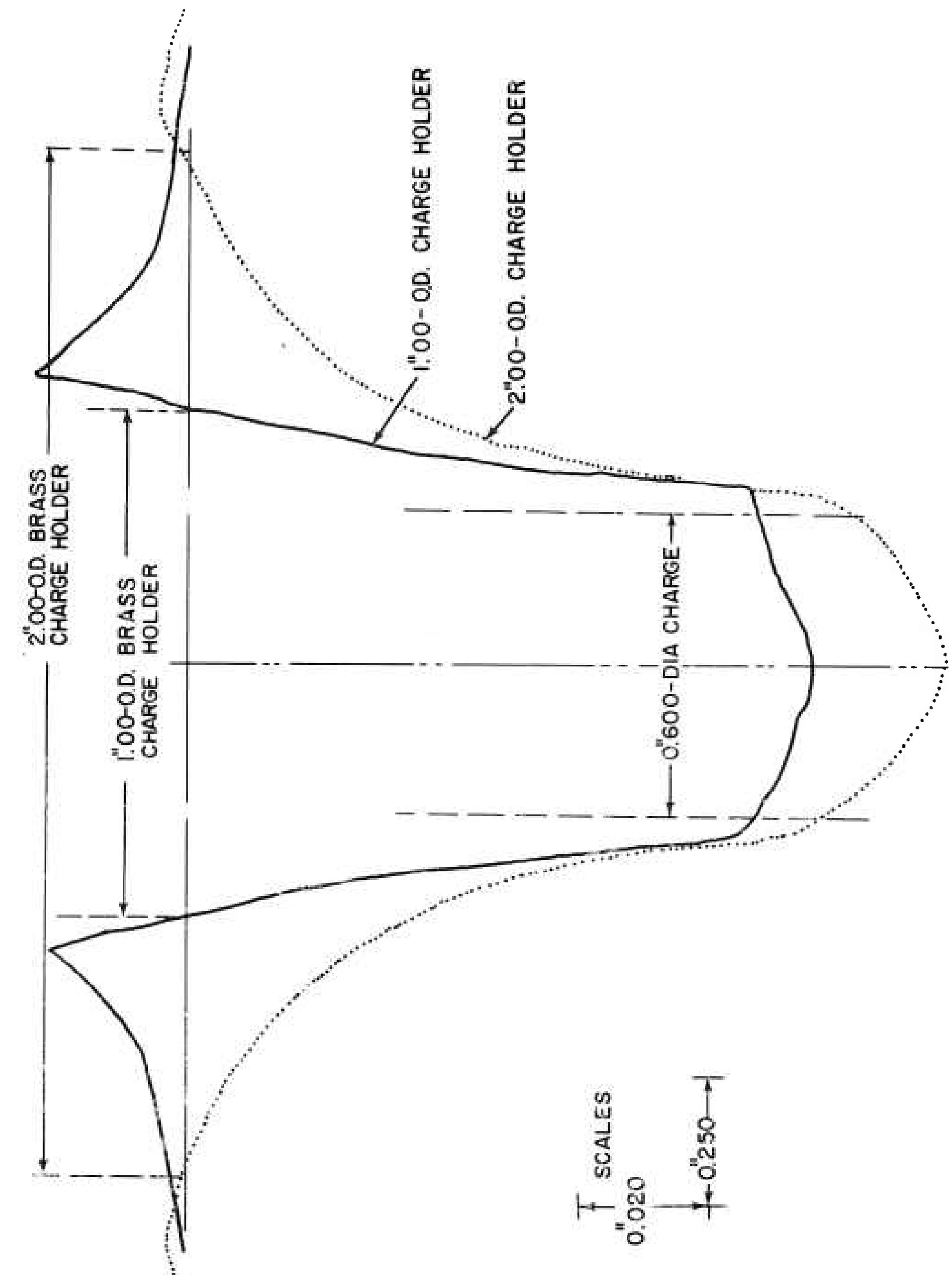

FIG. 8 EFFECT OF CHARGE HOLDER O.D. ON DENT PROFILE OF 0"600-DIA. CHARGES

TABLE 2

OUTPUT (EXPRESSED IN MILS) OF VARIOUS 1.0-INCH LONG DATB CHARGES, PRESSED AT 10K PSI IN 1.0-INCH DIAMETER BODIES

Acceptor Initiated by	Explosive Column Diameter (Inches)		
	0.1875	0.40	0.60
SSGT Donor (Strong Shock)	42.4	80.9	99.7
Detonator Mk 70 Mod 0	41.0	77.7	----
Detonator Mk 70 Mod 0 Attenuated by 64 mils Lucite (Weak Shock)	40.0	74.8	96.9

output of the DATB column when initiated by the weak shock is in the order of 5% less than when initiated by a strong shock.

In the final portion of this study unconfined 0.6-inch diameter pellets, used two at a time to give a 1.0-inch column length, were fired without confinement against a steel witness plate. The observed dent depth was about half that of the same column diameter when confined (Figure 3). Also the dent profile (Figure 9) was much less flat- bottomed indicating that the shock front was far from plane wave and that the peripheral explosive may have been contributing relatively little to the total explosive action. From this it can be seen that close confinement of the DATB greatly enhances its explosiveness in these small size charges.

CONCLUSIONS

In those weapon systems where a temperature-resistant explosive is needed for the explosive train components, i.e., in the leads and boosters, it should be possible to employ DATB. CH-6, which is in current use in a number of systems, can be used where the temperatures are in the order of 350° F. for short lengths of time 4/ 5/. DATB would be expected to withstand temperatures of about 100° F. higher than CH-6.*

The thermal advantage over CH-6 in using DATB will in part have to be paid for by a decrease in relative explosive strength and perhaps also by some changes in the loading methods to allow for the differences in physical properties of the two materials and also to increase the confinement in order to enhance the explosive vigor of DATB.

There is still another way to improve the DATB output over what was observed in this set of experiments. The charges in this study were only at about 80% of Theoretical Maximum density (TMD). By increasing the density the output can be increased considerably.6/ Such a change would have to be balanced off against the concomitant desensitization of the DATB charge which in turn can alter the probability of detonation transfer in the train. The choice of optimum TMD would of course require experimental work.

---

* The RDX used in CH-6 is Class A - - a material which by virtue of the manufacturing process contains up to about 10% HMX. The melting point of this material may be as low as 375°F. DATB has so far been produced with very nearly CP quality. A decrease in purity could sharply degrade its temperature-resistant properties as is often the case with other high-temperature explosives.

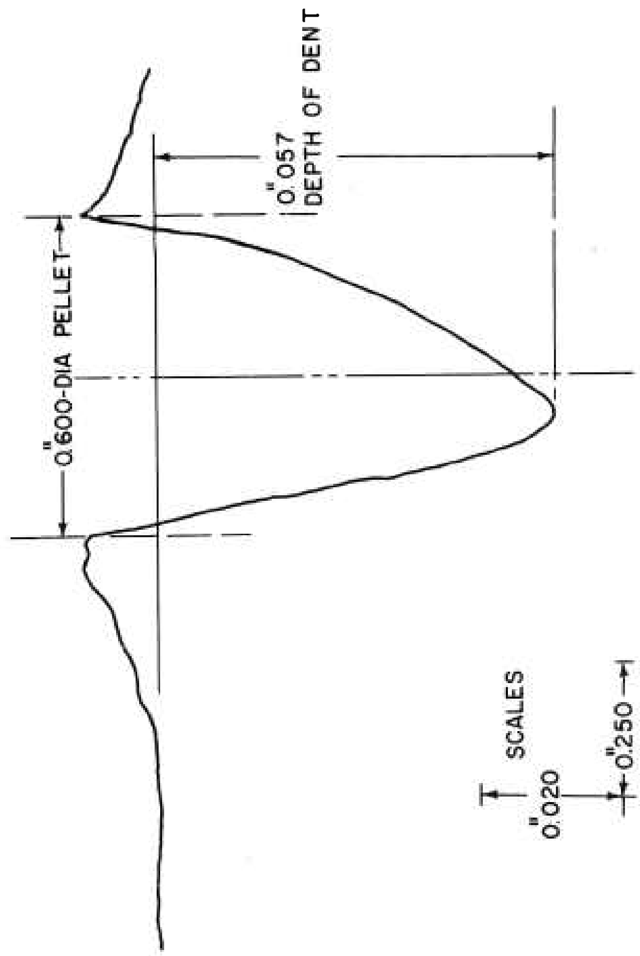

FIG. 9 DENT PROFILE: TWO 0.600" DIA PELLETS, TOTAL LENGTH≈1.00", NO CONFINEMENT

From Figure 2 it can be seen that the DATB should be usable as a lead explosive since it acts as an explosive amplifier. Furthermore it satisfies the requirement usually placed on fuze explosive trains, namely, that it can be used beyond the train interrupter since it is definitely less sensitive than tetryl.

It also appears to be feasible to use DATB as a booster explosive. But, as for the leads, it will be necessary to tinker with such variables as charge length, loading pressure, booster case wall thickness, and initiator strength to achieve an optimized design.

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APPENDIX A

TABLE A-1

OUTPUT OF VARIOUS DATB CHARGES PRESSED AT 10K PSI INTO 1.00 INCH O.D. BRASS BODIES AND INITIATED BY MK 70 DETONATORS

No attenuator Between Mk. 70 Detonator and DATB

Col. Diam.	0".1875	0".1875	0".1875	0".1875	0".40	0".60
Col. Length	0".25	0".50	0".75	1".00	1".00	1".00
Observed Dent (mils)	25.78 27.92 26.95 26.20	36.98 36.05* 31.42* 35.22	41.72 38.95 39.20 39.10	39.70 40.52 40.80 43.15	76.58 78.62 78.02 76.68	97.7 94.5 99.2 96.2

With Lucite Attenuator Between Mk. 70 Detonator and DATB

Col. Diam.	0".1875	0".1875	0".1875	0".1875	0".1875	0".40	0".1875
Col. Length	1".00	1".00	0".25	0".50	0".75	1".00	1".00
Attenuator (mils)	42	64	64	64	64	64	70
Observed Dent (mils)	41.55	38.35 40.02 40.62 40.88	23.90 25.32 22.85 24.00	32.90 34.62* 36.80* 32.50*	38.60 36.68 35.40 35.88	73.10 75.40 74.52 76.20	38.65 39.68 39.58 41.48

Normalized Data

Col. Diam.	0".40	0".60	0".40
Col. Length	1".00	1".00	1".00
Attenuator	none	none	64 mils
Dent (mils) Normalized to 0".1875 Col. Diam.	35.9 36.9 36.6 35.7	30.5 29.5 31.0 30.1	34.3 35.3 34.9 35.7

*Expanded acceptor body without shattering it.

TABLE A-2

OUTPUT OF VARIOUS DATB CHARGES PRESSED AT 10K PSI INTO 1.00 INCH O.D. BRASS BODIES AND INITIATED BY SSGT DONORS

Col. Diam.	0"10	0"15	0"1875	0"1875	0"1875	0"1875	0"20
Col. Length	1"00	1"00	0"25	0"50	0"75	1"00	1"00
Observed Dent (mils)	18.72	31.25	56.35	49.65	43.25	41.28	44.38
	21.20	30.78	57.40	48.25	45.95	42.08	47.38
	21.80	32.60	54.95	48.05	46.42	42.58	47.90
	20.50	32.95	55.22	48.82	45.12	43.62	47.70

Col. Diam.	0"25	0"30	0"40	0"50	0"60
Col. Length	1"00	1"00	1"00	1"00	
Observed Dent (mils)	62.50	69.98	80.28	93.5	96.6
	59.25	70.05	79.35	94.8	100.5
	60.20	70.32	81.40	95.8	102.0
	61.58	75.50	82.68	94.5	99.5
				90.8	

Col. Diam.	0"10	0"15	0"20	0"25	0"30	0"40	0"50	0"60
Col. Length	1"00	1"00	1"00	1"00	1"00	1"00	1"00	1"00
Dent (mils) Normalized to 0"1875 Column Diameter	35.1	39.1	41.6	46.9	43.7	37.6	35.1	30.2
	39.8	38.5	44.4	44.4	43.8	37.2	35.6	31.4
	40.9	40.8	44.9	45.2	44.0	38.2	35.9	31.9
	38.4	41.2	44.7	46.2	47.2	38.8	35.4	31.1
							34.1	

TABLE A-3

OUTPUT OF VARIOUS 1.0 INCH LONG DATB CHARGES PRESSED AT 10K PSI

Column Diameter	0".3	0".4	0".5	0".6	0".6*	0".6*
Body O. D.	2".0	2".0	2".0	2".0	None	None
Initiator Type	SSGT Donor	SSGT Donor	SSGT Donor	SSGT Donor	SSGT Donor	Mk 70 Det.
Observed Dent (mils)	59.5 62.0 59.0 60.8	80.8 79.0 77.8 77.2	91.5 97.2 94.5 94.8	109.0 113.2 111.5 113.0	59.0 56.0 55.0 55.0	55.2 53.8 56.8 58.0
Dent (mils) Normalized to 0".1875 Column Diameter	37.2 38.8 36.9 38.0	37.9 37.0 36.5 36.2	34.3 36.5 35.4 35.6	34.1 35.4 34.8 35.3	18.4 17.5 17.2 17.2	17.3 16.8 17.8 18.1

*2 pellets, total length approximately 1.0 inch

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REPORT DATE	15 May 1963	Ø563	CIRCULATION LIMITATION OR BIBLIOGRAPHIC		
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SUBJECT ANALYSIS OF REPORT

DESCRIPTORS	CODES	DESCRIPTORS	CODES	DESCRIPTORS	CODES
Explosive	EXPL	Loaded	LOAI		
Fill	FILL	Axially	AXIA		
Leads	LEAS	Drilled	DRLL		
Boosters	BOOS	Brass	BRAS		
Heat-resistant	HEAA	Metal	META		
Charges	CHAR	Cylinders	CYLI		
Sensitivity	SENV	Explosives (tests)	EXPLT		
Diamino	DIAM	High temperature	HTEM		
Trinitro	TRIT	Temperature	TEMP		
Benzene	BENZ	Decoupling	DECU		
Confined	CTAI	Column	COLU		
Press	PRSG	Diameter	DIAM		

PRNC-NOL-5070/28 (5-62)

Naval Ordnance Laboratory, White Oak, Md.
(NOL technical report 63-50)
A HEAT RESISTANT EXPLOSIVE FILL FOR LEADS AND BOOSTERS (U), by J. N. Ayres and L. D. Hampton. 15 May 1963. 21p. illus., tables. BuWeps task RUME-4E-000/212-1/F008-10-004.
CONFIDENTIAL

The sensitivity of small highly confined charges of a heat resistant explosive has been investigated. The charges were press-loaded into axially drilled brass cylinders, either 1.0-inch of 2.0-inches outside diameter, 0.1 to 0.6-inch inside diameter, and 0.25 to 1.0 inches in length. The investigation was a preliminary survey from which it is held that the heat resistant explosive investigated has sufficient sensitivity to be used as an explosive fill for leads and boosters.
Abstract card is unclassified

1. Explosives, Heat resistant
2. Diaminotrinitrobenzene
3. Leads, Explosive
4. Boosters, Explosive

I. Title
II. Ayres, James N.
III. Hampton, Laurence D., jt. author
IV. Project

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